

## Rail-to-rail micropower BiCMOS comparators

### Features

- Ultra low current consumption (6  $\mu\text{A}/\text{comp}$  at  $V_{\text{CC}} = 2.7\text{ V}$ )
- Rail to rail CMOS inputs
- Push pull outputs
- Supply operation from 2.7 to 10 V
- Low propagation delay
- ESD protection (2 kV)
- Latch-up immunity (class A)
- Available in SOT23-5 micropackage

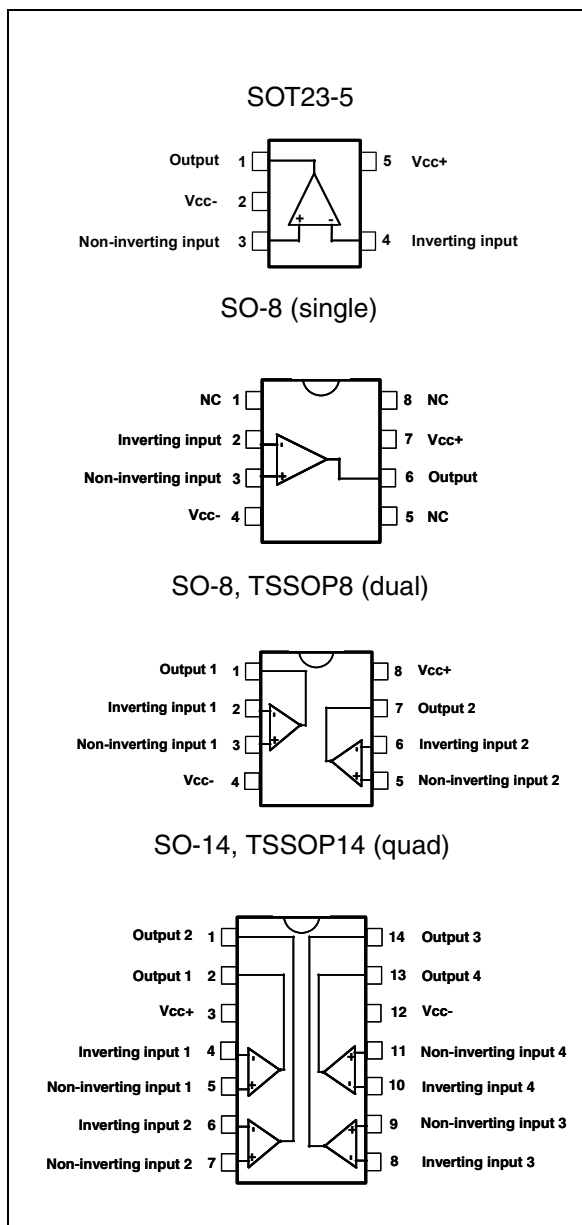
### Applications

- Battery-powered systems such as alarms
- Portable communication systems
- Smoke/gas/fire detectors
- Portable computers

### Description

The TS86x (single, dual and quad) is a rail-to-rail comparator characterized for 2.7 to 10 V operation over  $-40^{\circ}\text{ C}$  to  $+85^{\circ}\text{ C}$  temperature ranges. It exhibits an excellent speed-to-power ratio, featuring a current consumption of 6  $\mu\text{A}$  per comparator and a response time of 500 ns at 2.7 V for a 100 mV overdrive.

Due to its ultra-low power consumption and its availability in a tiny package, the TS86x comparator family is perfectly suited to battery-powered systems. The output stage is designed with a push-pull structure allowing a direct connection to the microcontroller without additional pull-up resistors.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply voltage <sup>(1)</sup>	12	V
V <sub>ID</sub>	Differential Input Voltage <sup>(2)</sup>	±12	V
V <sub>IN</sub>	Input Voltage Range <sup>(3)</sup>	-0.3 to 12.3	V
R <sub>THJA</sub>	Thermal resistance junction to ambient <sup>(4)</sup>		
	SOT23-5	250	°C/W
	SO8	125	
	SO14	105	
	TSSOP8	120	
TSSOP14	100		
R <sub>THJC</sub>	Thermal resistance junction to case <sup>(4)</sup>		
	SOT23-5	81	°C/W
	SO8	40	
	SO14	31	
	TSSOP8	37	
TSSOP14	32		
T <sub>STG</sub>	Storage temperature range	-65 to +150	°C
T <sub>J</sub>	Maximum junction temperature	150	°C
T <sub>LEAD</sub>	Lead temperature (soldering, 10 sec)	260	°C
ESD	Human body model (HBM) <sup>(5)</sup>	2	kV
	Machine model (MM) <sup>(6)</sup>	200	V
	Latch-up immunity	Class A	

1. All voltages values, except differential voltage are with respect to network terminal.
2. Differential voltages are non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed V<sub>CC</sub> +0.3V.
4. Short-circuits can cause excessive heating. These values are typical.
5. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
6. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply voltage	2.7 to 10	V
V <sub>ICM</sub>	Common mode input voltage range	V <sub>CC</sub> <sup>-</sup> - 0.3 to V <sub>CC</sub> <sup>+</sup> + 0.3	V
T <sub>Oper</sub>	Operating free air temperature range	-40 to + 85	°C

## 2 Electrical characteristics

**Table 3. Electrical characteristics at  $V_{CC} = 2.7\text{ V}$ ,  $T_{amb} = 25^\circ\text{ C}$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{IO}$	Input offset voltage TS861/2/4 $T_{min} < T < T_{max}$		3	15 18	mV
	TS861/2/4A $T_{min} < T < T_{max}$		3	7 10	
$\Delta V_{IO}$	Input offset voltage drift		6		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$	Input offset current <sup>(1)</sup> $T_{min} < T < T_{max}$		1	150 300	pA
$I_{IB}$	Input bias current <sup>(1)</sup> $T_{min} < T < T_{max}$		1	300 600	pA
$V_{OH}$	High level output voltage $I_{SOURCE} = 2.5\text{ mA}$ $T_{min} < T < T_{max}$	2.35 2.15	2.45		V
$V_{OL}$	Low level output voltage $I_{SINK} = 2.5\text{ mA}$ $T_{min} < T < T_{max}$		0.2	0.35 0.45	V
$A_{VD}$	Large signal voltage gain <sup>(2)</sup>		240		dB
CMR	Common mode rejection ratio $0 < V_{ICM} < 2.7\text{ V}$		65		dB
SVR	Supply voltage rejection ratio $0 < V_{CC} < 10\text{ V}$		80		dB
$I_{CC}$	Supply current per comparator no load, output low no load, output high		6 8	12 14	$\mu\text{A}$
$T_{PLH}$	Propagation delay from output low to output high $V_{ICM} = 1.35\text{ V}$ , $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV		1.5 0.6		$\mu\text{s}$
$T_{PHL}$	Propagation delay from output high to output low $V_{ICM} = 1.35\text{ V}$ , $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV		1.5 0.5		$\mu\text{s}$

**Table 3. Electrical characteristics at  $V_{CC} = 2.7\text{ V}$ ,  $T_{amb} = 25^\circ\text{ C}$   
(unless otherwise specified) (continued)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$T_F$	Fall time f = 10 kHz, $C_L = 50\text{ pF}$ , overdrive = 100 mV		20		ns
$T_R$	Rise time f = 10 kHz, $C_L = 50\text{ pF}$ , overdrive = 100 mV		20		ns

1. Maximum values including unavoidable inaccuracies of the industrial tests.
2. Design evaluation.

*Note: Limits are 100% production tested at 25° C. Limits over temperature are guaranteed through correlation and by design.*

**Table 4. Electrical characteristics at  $V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25^\circ\text{ C}$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{IO}$	Input offset voltage TS861/2/4 $T_{min} < T < T_{max}$		3	15 18	mV
	TS861/2/4A $T_{min} < T < T_{max}$		3	7 10	
$\Delta V_{IO}$	Input offset voltage drift		6		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$	Input offset current <sup>(1)</sup> $T_{min} < T < T_{max}$		1	150 300	pA
$I_{IB}$	Input bias current <sup>(1)</sup> $T_{min} < T < T_{max}$		1	300 600	pA
$V_{OH}$	High level output voltage $I_{SOURCE} = 5\text{ mA}$ $T_{min} < T < T_{max}$	4.6 4.45	4.8		V
$V_{OL}$	Low level output voltage $I_{SINK} = 5\text{ mA}$ $T_{min} < T < T_{max}$		0.2	0.4 0.55	V
$A_{VD}$	Large signal voltage gain <sup>(2)</sup>		240		dB
CMR	Common mode rejection ratio $0 < V_{ICM} < 5\text{ V}$		70		dB
SVR	Supply voltage rejection ratio $2.7 < V_{CC} < 10\text{ V}$		80		dB
$I_{CC}$	Supply current per comparator no load, output low no load, output high		6 8	12 14	$\mu\text{A}$
$T_{PLH}$	Propagation delay from output low to output high $V_{ICM} = 2.5\text{ V}$ , $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV		2 0.5		$\mu\text{s}$
$T_{PHL}$	Propagation delay from output high to output low $V_{ICM} = 2.5\text{ V}$ , $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV		2 0.4		$\mu\text{s}$
$T_F$	Fall time $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ , overdrive = 100 mV		20		ns
$T_R$	Rise time $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ , overdrive = 100 mV		20		ns

1. Maximum values including unavoidable inaccuracies of the industrial test.

2. Design evaluation.

**Note:** Limits are 100% production tested at 25°C. Limits over temperature are guaranteed through correlation and by design.

**Table 5. Electrical characteristics at  $V_{CC} = +10\text{ V}$ ,  $T_{amb} = 25^\circ\text{ C}$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{IO}$	Input offset voltage ( $V_{ICM} = V_{CC} / 2$ ) TS861/2/4 $T_{min} < T < T_{max}$		3	15 18	mV
$\Delta V_{IO}$	Input offset voltage drift		6		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$	Input offset current <sup>(1)</sup> $T_{min} < T < T_{max}$		1	150 300	pA
$I_{IB}$	Input bias current <sup>(1)</sup> $T_{min} < T < T_{max}$		1	300 600	pA
$V_{OH}$	High level output voltage $I_{SOURCE} = 5\text{ mA}$ $T_{min} < T < T_{max}$	9.6 9.45	9.8		V
$V_{OL}$	Low level output voltage $I_{SINK} = 5\text{ mA}$ $T_{min} < T < T_{max}$		0.2	0.4 0.55	V
$A_{VD}$	Large signal voltage gain <sup>(2)</sup>		240		dB
CMR	Common mode rejection ratio $0 < V_{ICM} < 10\text{ V}$		75		dB
SVR	Supply voltage rejection ratio $2.7 < V_{CC} < 10\text{ V}$		80		dB
$I_{CC}$	Supply current per comparator no load, output low no load, output high		7 10	14 16	$\mu\text{A}$
$T_{PLH}$	Propagation delay from output low to output high $V_{ICM} = 5\text{ V}$ , $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV		3 0.5		$\mu\text{s}$
$T_{PHL}$	Propagation delay from output high to output low $V_{ICM} = 5\text{ V}$ , $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ overdrive = 10 mV overdrive = 100 mV		2.6 0.4		$\mu\text{s}$
$T_F$	Fall time $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ , overdrive = 100 mV		20		ns
$T_R$	Rise time $f = 10\text{ kHz}$ , $C_L = 50\text{ pF}$ , overdrive = 100 mV		20		ns

1. Maximum values including unavoidable inaccuracies of the industrial test.

2. Design evaluation.

**Note:** Limits are 100% production tested at  $25^\circ\text{ C}$ . Limits over temperature are guaranteed through correlation and by design.

Figure 1.  $V_{IO}$  versus  $V_{ICM}$  at  $V_{CC} = 2.7\text{ V}$

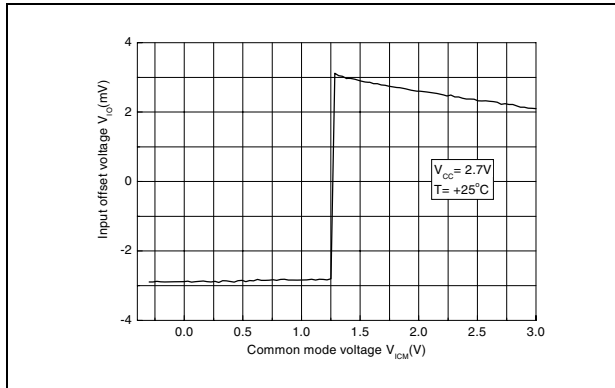


Figure 2.  $V_{IO}$  versus  $V_{ICM}$  and temperature at  $V_{CC} = 2.7\text{ V}$

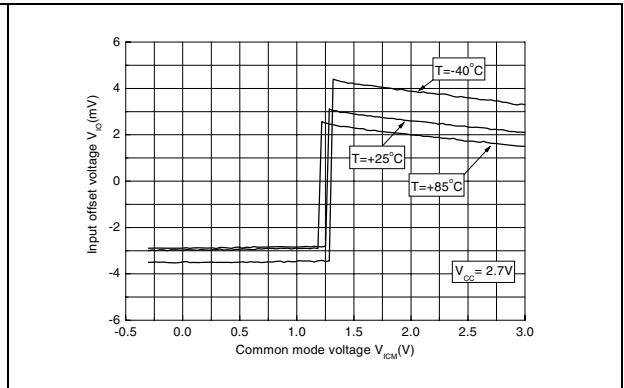


Figure 3.  $V_{IO}$  versus  $V_{ICM}$  at  $V_{CC} = 5\text{ V}$

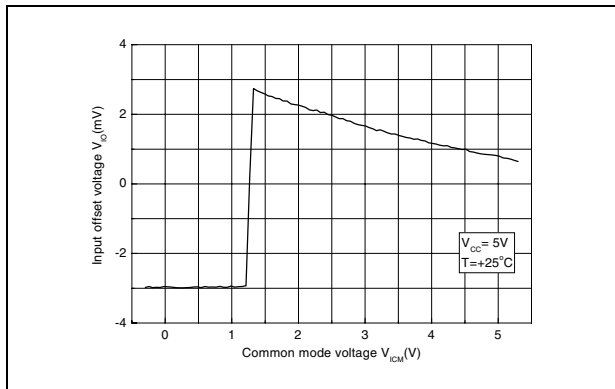


Figure 4.  $V_{IO}$  versus  $V_{ICM}$  and temperature at  $V_{CC} = 5\text{ V}$

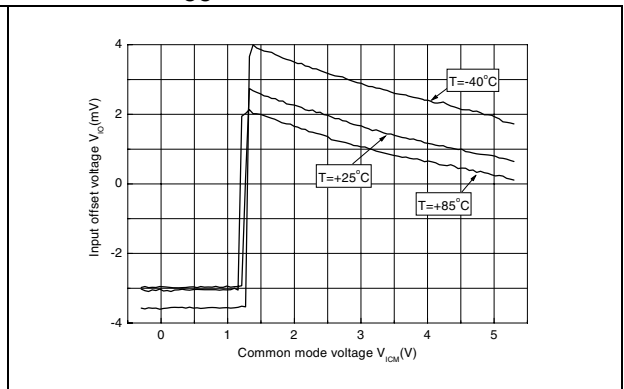


Figure 5.  $V_{IO}$  versus  $V_{ICM}$  at  $V_{CC} = 10\text{ V}$

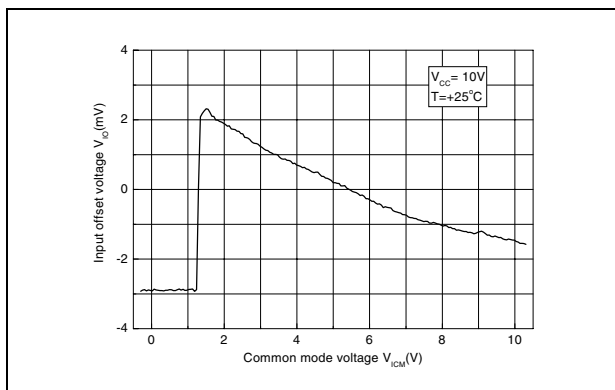


Figure 6.  $V_{IO}$  versus  $V_{ICM}$  and temperature at  $V_{CC} = 10\text{ V}$

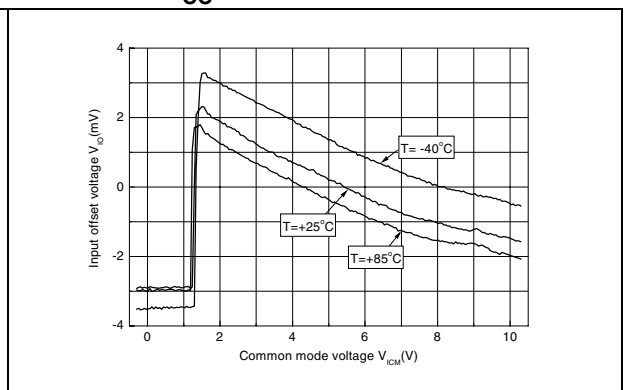


Figure 7.  $V_{IO}$  versus  $V_{CC}$  at  $V_{ICM} = V_{CC}/2$

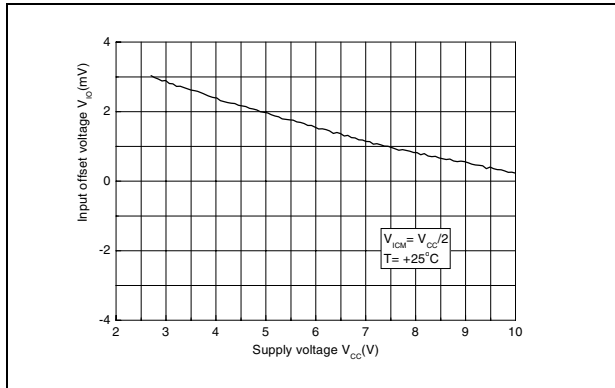


Figure 8.  $V_{IO}$  versus temperature at  $V_{CC} = 5\text{ V}$

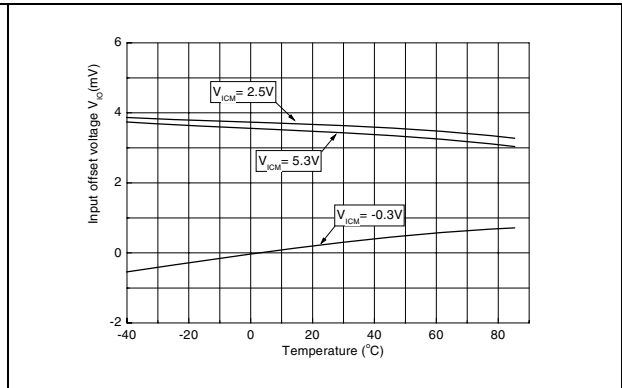


Figure 9. Supply current ( $I_{CC}$ ) versus supply voltage ( $V_{CC}$ )

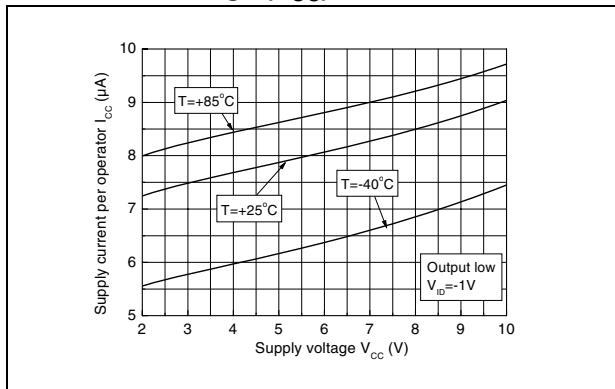


Figure 10. Supply current ( $I_{CC}$ ) versus supply voltage ( $V_{CC}$ )

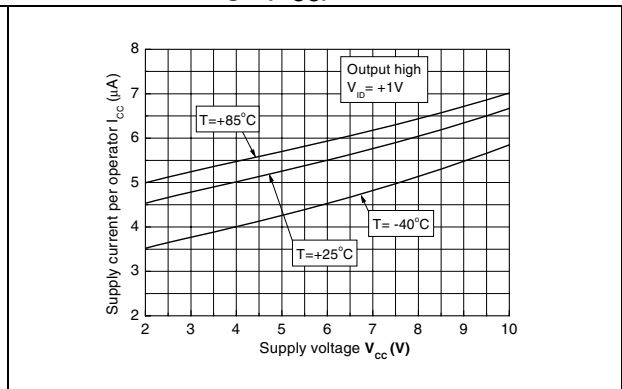


Figure 11. Supply current ( $I_{CC}$ ) versus temperature

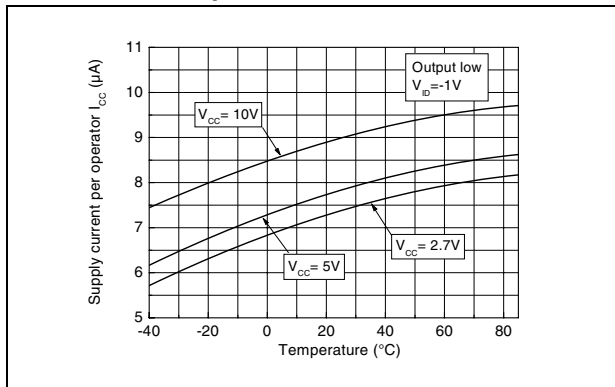


Figure 12. Supply current ( $I_{CC}$ ) versus temperature

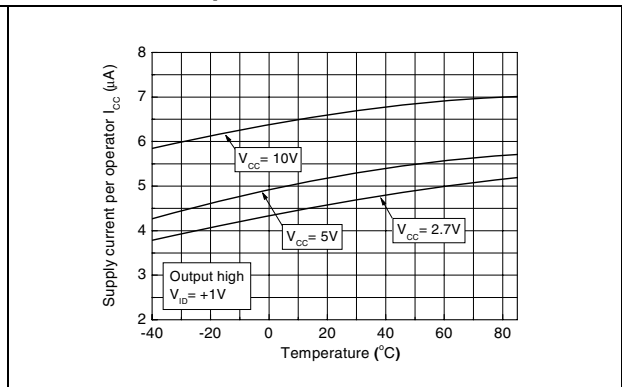




Figure 13.  $V_{OL}$  versus  $I_{SINK}$  and temperature at  $V_{CC} = 5\text{ V}$

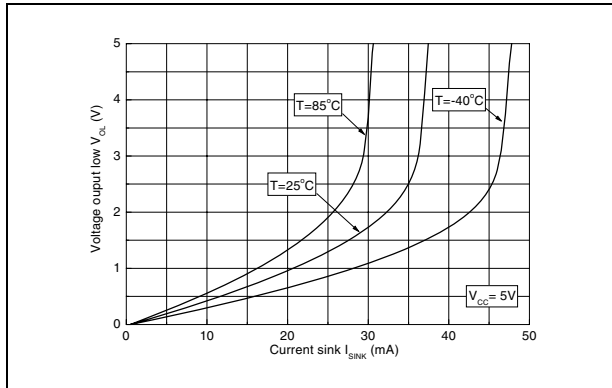


Figure 14.  $V_{OH}$  versus  $I_{SOURCE}$  and temperature at  $V_{CC} = 5\text{ V}$

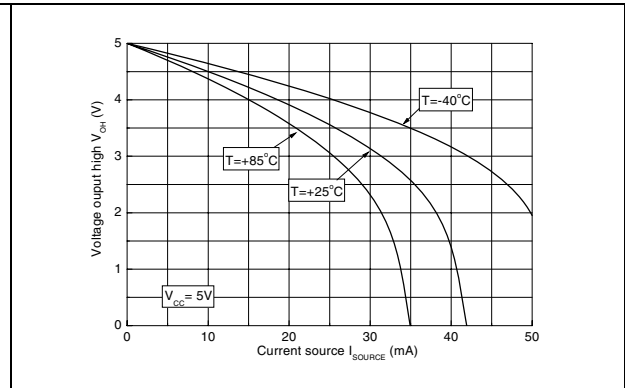


Figure 15. Propagation delay  $T_{PLH}$  versus  $V_{ICM}$  with  $V_{OVD} = 100\text{ mV}$

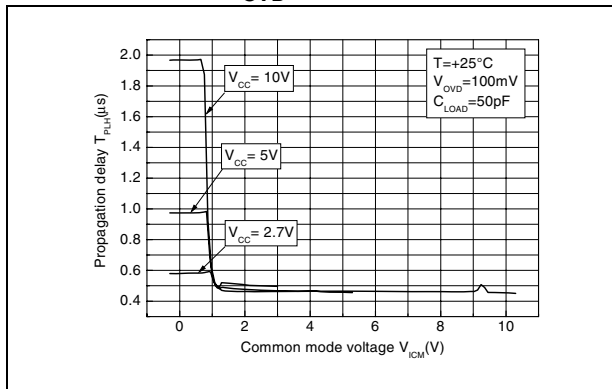


Figure 16. Propagation delay  $T_{PHL}$  versus  $V_{ICM}$  with  $V_{OVD} = 100\text{ mV}$

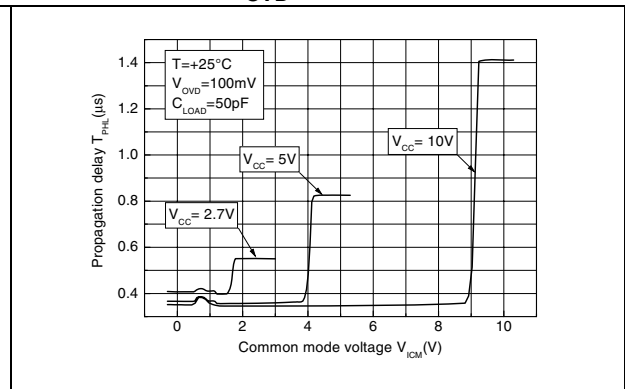


Figure 17. Propagation delay  $T_{PLH}$  versus  $V_{ICM}$  with  $V_{OVD} = 10\text{ mV}$

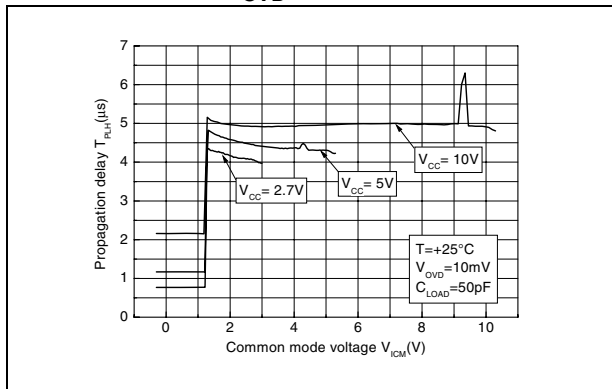


Figure 18. Propagation delay  $T_{PHL}$  versus  $V_{ICM}$  with  $V_{OVD} = 10\text{ mV}$

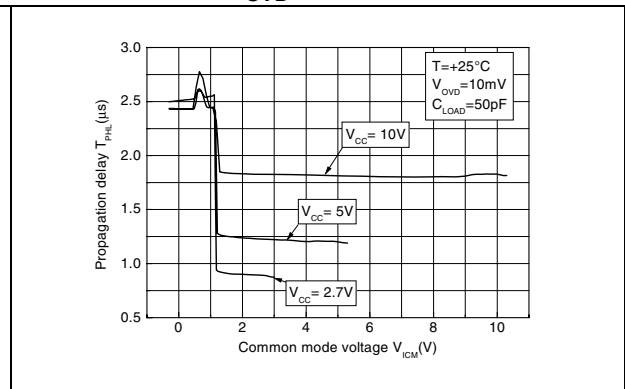


Figure 19. Propagation delay versus  $V_{CC}$  with  $V_{OVD} = 10\text{ mV}$

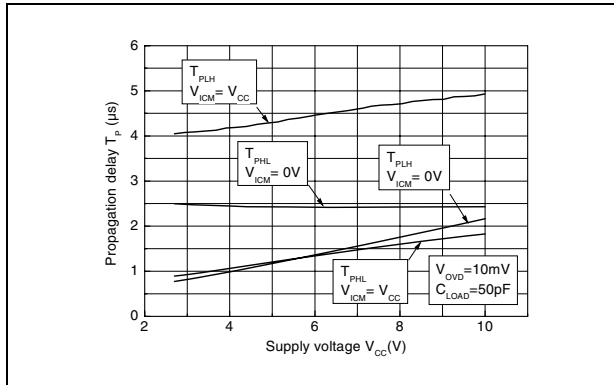


Figure 20. Propagation delay versus  $V_{CC}$  with  $V_{OVD} = 100\text{ mV}$

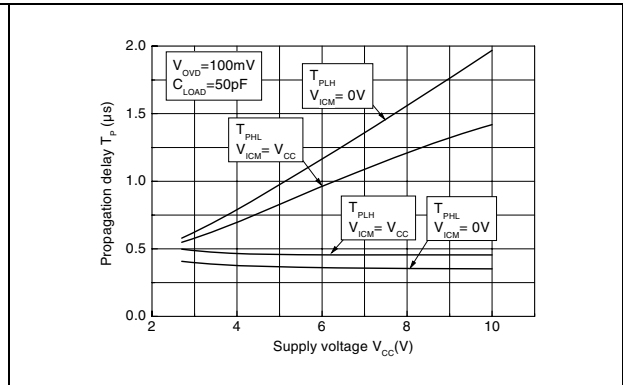


Figure 21. Propagation delay versus overdrive voltage at  $V_{CC} = 2.7\text{ V}$

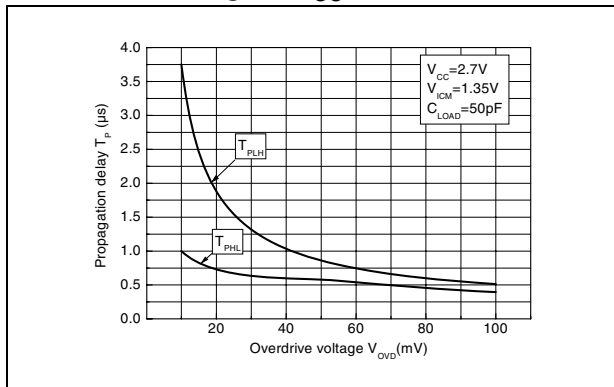


Figure 22. Propagation delay versus overdrive voltage at  $V_{CC} = 5\text{ V}$

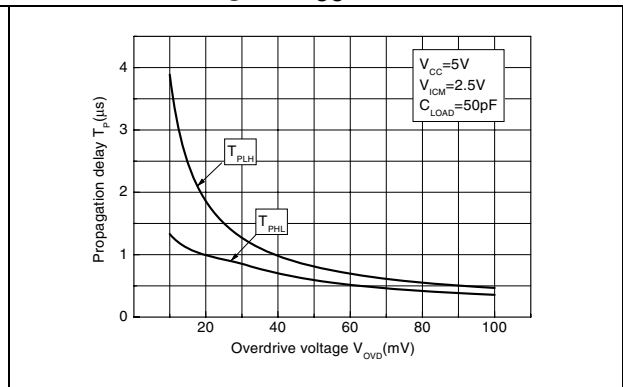
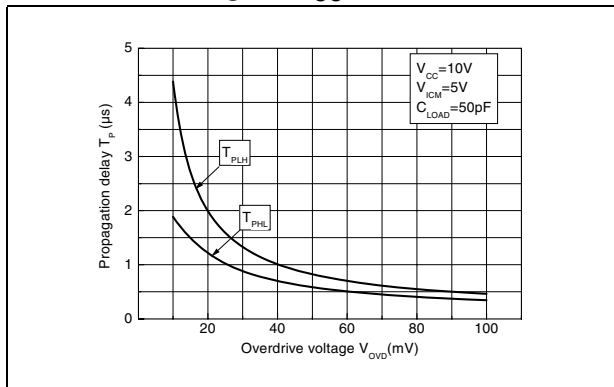


Figure 23. Propagation delay versus overdrive voltage at  $V_{CC} = 10\text{ V}$



### 3 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 3.1 SO-8 package information

Figure 24. SO-8 package mechanical drawing

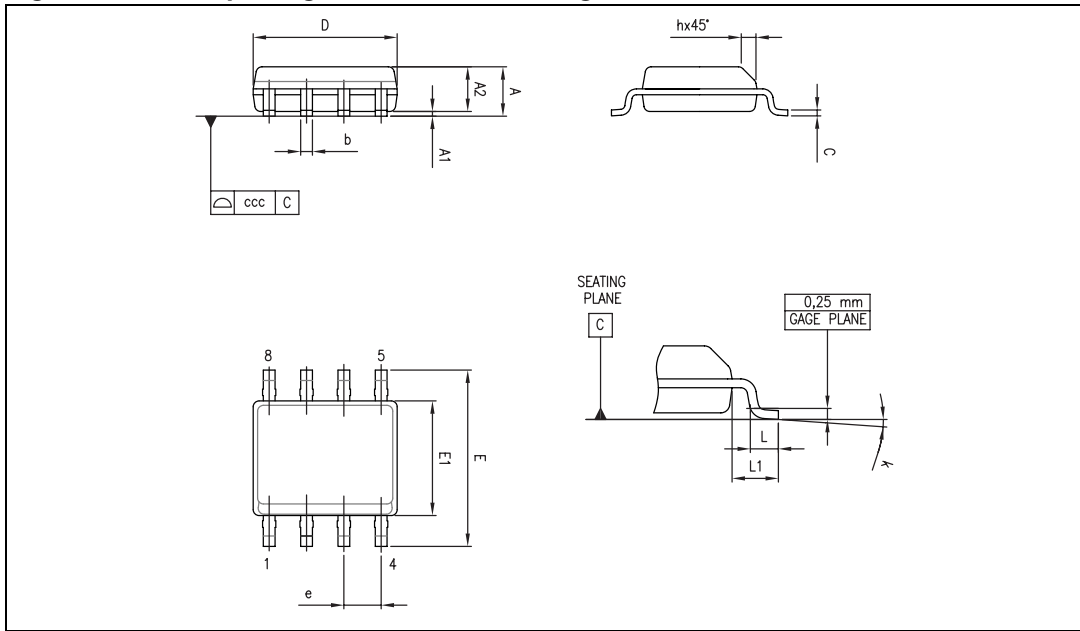


Table 6. SO-8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
c	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
L1		1.04			0.040	
k	0		8°	1°		8°
ccc			0.10			0.004

### 3.2 TSSOP8 package information

Figure 25. TSSOP8 package mechanical drawing

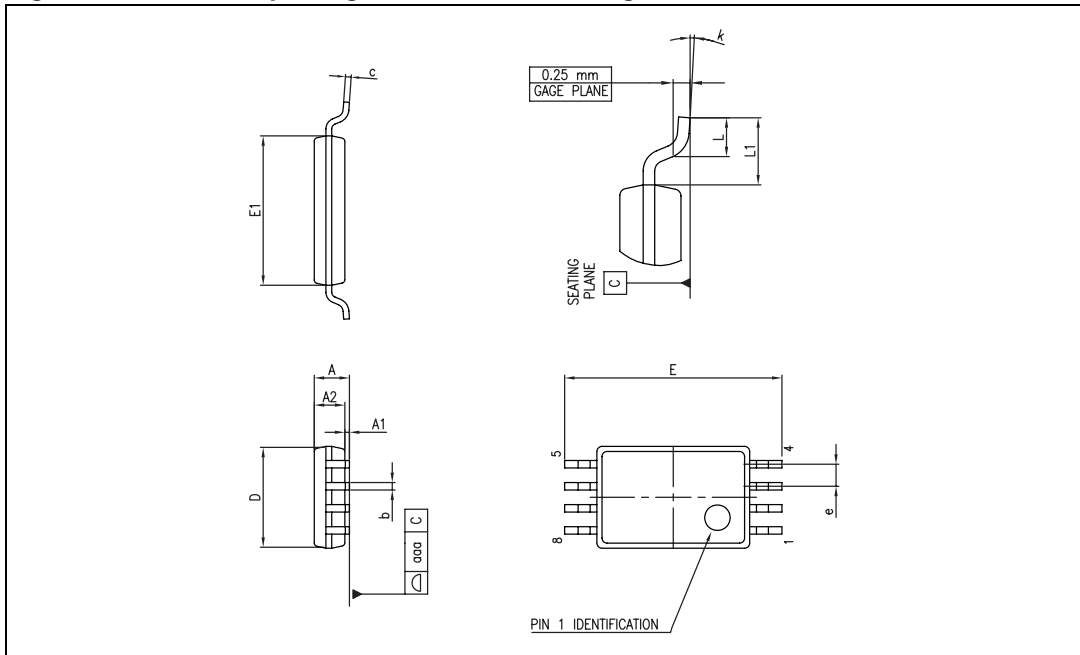


Table 7. TSSOP8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256	
k	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1			0.039	
aaa			0.10			0.004

### 3.3 SO-14 package information

Figure 26. SO-14 package mechanical drawing

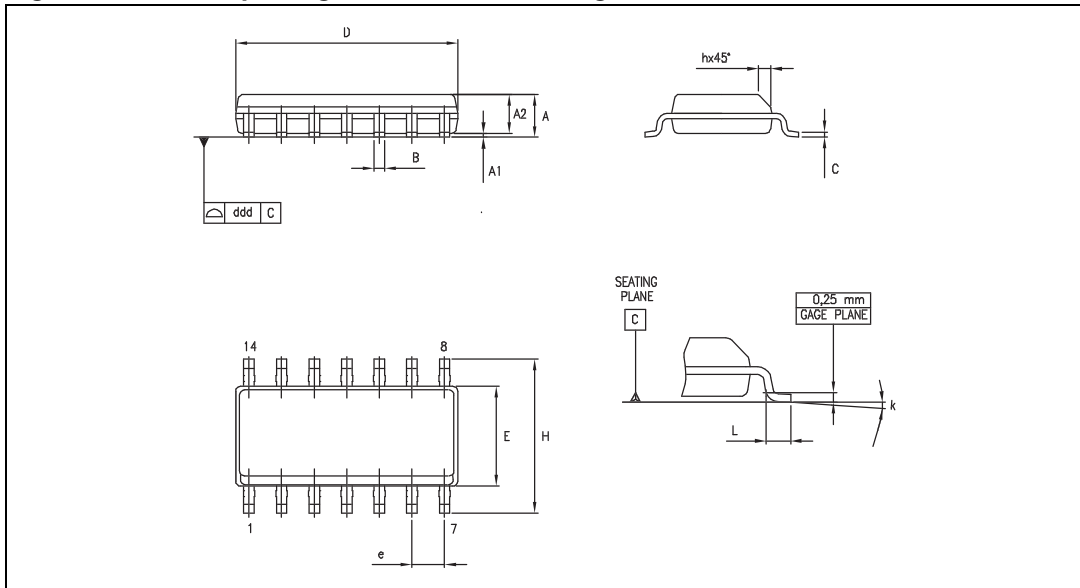


Table 8. SO-14 package mechanical data

Dimensions						
Ref.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.05		0.068
A1	0.10		0.25	0.004		0.009
A2	1.10		1.65	0.04		0.06
B	0.33		0.51	0.01		0.02
C	0.19		0.25	0.007		0.009
D	8.55		8.75	0.33		0.34
E	3.80		4.0	0.15		0.15
e		1.27			0.05	
H	5.80		6.20	0.22		0.24
h	0.25		0.50	0.009		0.02
L	0.40		1.27	0.015		0.05
k	8° (max.)					
ddd			0.10			0.004

### 3.4 TSSOP14 package information

Figure 27. TSSOP14 package mechanical drawing

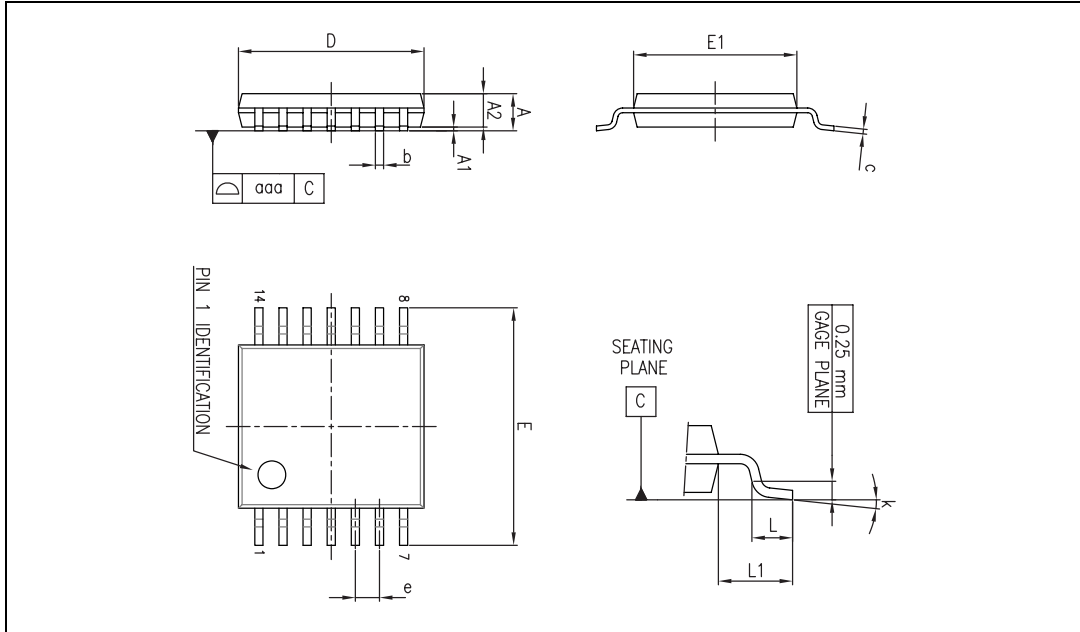


Table 9. TSSOP14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.176
e		0.65			0.0256	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
k	0°		8°	0°		8°
aaa			0.10			0.004

### 3.5 SOT23-5 package information

Figure 28. SOT23-5L package mechanical drawing

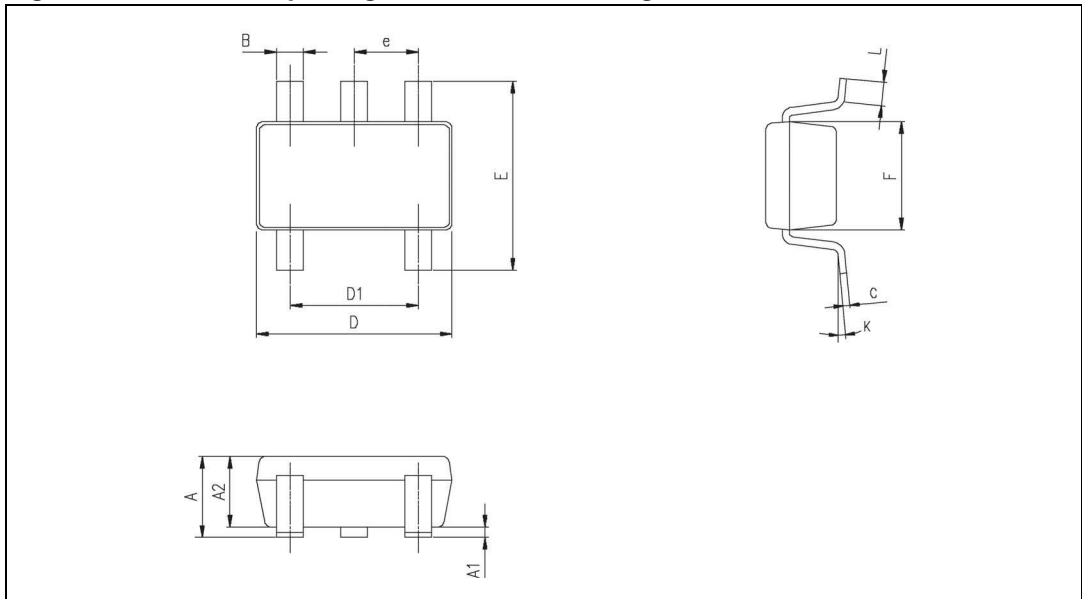


Table 10. SOT23-5L package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	1.20	1.45	0.035	0.047	0.057
A1			0.15			0.006
A2	0.90	1.05	1.30	0.035	0.041	0.051
B	0.35	0.40	0.50	0.013	0.015	0.019
C	0.09	0.15	0.20	0.003	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
D1		1.90			0.075	
e		0.95			0.037	
E	2.60	2.80	3.00	0.102	0.110	0.118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.10	0.35	0.60	0.004	0.013	0.023
K	0 degrees		10 degrees			



## 4 Ordering information

Table 11. Order codes

Part number	Temperature range	Package	Packing	Marking
TS861ILT TS861AILT	-40°C, +85°C	SOT-23	Tape & reel	K501 K502
TS861ID TS861IDT		SO-8	Tube Tape & reel	861I
TS861AID TS861AIDT			Tube Tape & reel	861AI
TS861IYLT <sup>(1)</sup> TS861AIYLT <sup>(1)</sup>		SOT-23 (Automotive grade)	Tape & reel	K504 K505
TS862ID TS862IDT	-40°C, +85°C	SO-8	Tube Tape & reel	862I
TS862AID TS862AIDT			Tube Tape & reel	862AI
TS862IPT TS862AIPT		TSSOP8	Tape & reel	862I 862AI
TS862IYDT <sup>(1)</sup> TS862AIYDT <sup>(1)</sup>		SO-8 (Automotive grade)	Tape & reel	862IY 862AIY
TS864ID TS864IDT	-40°C, +85°C	SO-14	Tube Tape & reel	864I
TS864AID TS864AIDT			Tube Tape & reel	864AI
TS864IPT TS864AIPT		TSSOP14	Tape & reel	864I 864AI
TS864IYDT <sup>(1)</sup> TS864AIYDT <sup>(1)</sup>		SO-14 (Automotive grade)	Tape & reel	864IY 864AIY

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

## 5 Revision history

**Table 12. Document revision history**

Date	Revision	Changes
01-Feb-2002	1	Initial release.
28-Apr-2009	2	Updated document format. Removed power dissipation from <a href="#">Table 1: Absolute maximum ratings</a> . Added Rthja and Rthjc values and ESD notes in <a href="#">Table 1</a> . Updated curves in <a href="#">Figure 1</a> to <a href="#">Figure 14</a> . Changed <a href="#">Figure 15</a> , <a href="#">Figure 16</a> , <a href="#">Figure 17</a> and <a href="#">Figure 18</a> . Added <a href="#">Figure 19</a> , <a href="#">Figure 20</a> , <a href="#">Figure 21</a> , <a href="#">Figure 22</a> and <a href="#">Figure 23</a> . Removed DIP package information in <a href="#">Chapter 3</a> and <a href="#">Chapter 4</a> . Added ordering information in <a href="#">Table 11: Order codes</a> .

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